

CMOS Digital Integrated Circuits Silicon Monolithic

TC74VCX574FT

1. Functional Description

- Low-Voltage Octal D-Type Flip-Flop with 3.6-V Tolerant Inputs and Outputs

2. General

The TC74VCX574FT is a high performance CMOS octal D-type flip-flop which is guaranteed to operate from 1.2 V to 3.6 V. Designed for use in 1.5 V, 1.8 V, 2.5 V or 3.3 V systems, it achieves high speed operation while maintaining the CMOS low power dissipation.

It is also designed with over voltage tolerant inputs and outputs up to 3.6 V.

This 8 bit D-type flip-flop is controlled by a clock input (CK) and an output enable input (\overline{OE}). When the \overline{OE} input is high, the eight outputs are in a high impedance state.

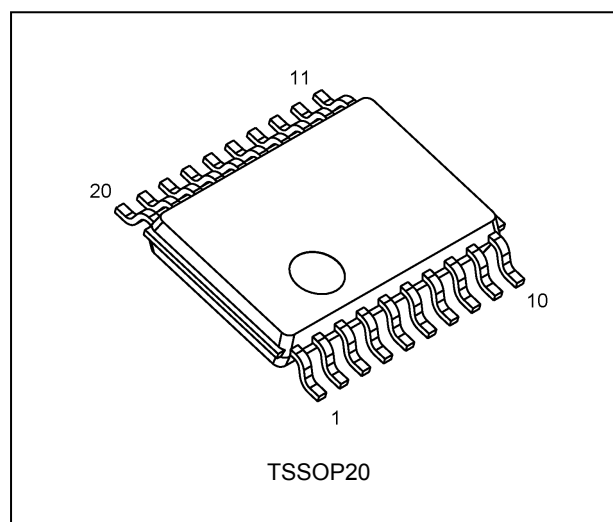
All inputs are equipped with protection circuits against static discharge.

3. Features

- (1) Wide operating temperature range: $T_{opr} = -40$ to 125 °C (Note 1)
- (2) Low-voltage operation: $V_{CC} = 1.2$ to 3.6 V
- (3) High-speed operation: $t_{pd} = 4.2$ ns (max) ($V_{CC} = 3.0$ to 3.6 V)
 $t_{pd} = 4.8$ ns (max) ($V_{CC} = 2.3$ to 2.7 V)
 $t_{pd} = 9.6$ ns (max) ($V_{CC} = 1.65$ to 1.95 V)
 $t_{pd} = 19.2$ ns (max) ($V_{CC} = 1.4$ to 1.6 V)
 $t_{pd} = 48.0$ ns (max) ($V_{CC} = 1.2$ V)
- (4) Output current: $I_{OH}/I_{OL} = \pm 24$ mA (min) ($V_{CC} = 3.0$ V)
 $I_{OH}/I_{OL} = \pm 18$ mA (min) ($V_{CC} = 2.3$ V)
 $I_{OH}/I_{OL} = \pm 6$ mA (min) ($V_{CC} = 1.65$ V)
 $I_{OH}/I_{OL} = \pm 2$ mA (min) ($V_{CC} = 1.4$ V)
- (5) 3.6 V tolerant function and power-down protection provided on all inputs and outputs.

Note 1: Operating Range spec of $T_{opr} = -40$ °C to 125 °C is applicable only for the products which manufactured after April 2020.

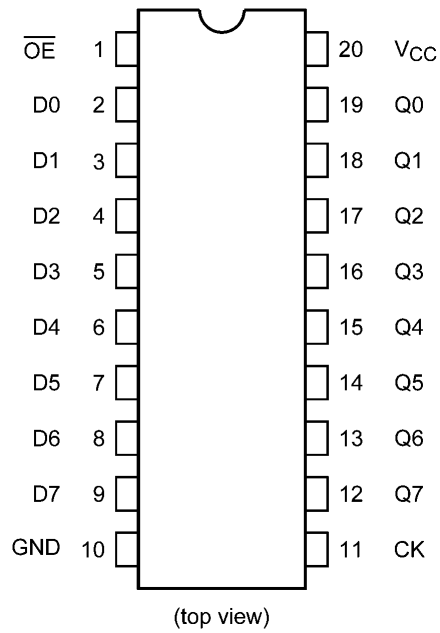
4. Packaging



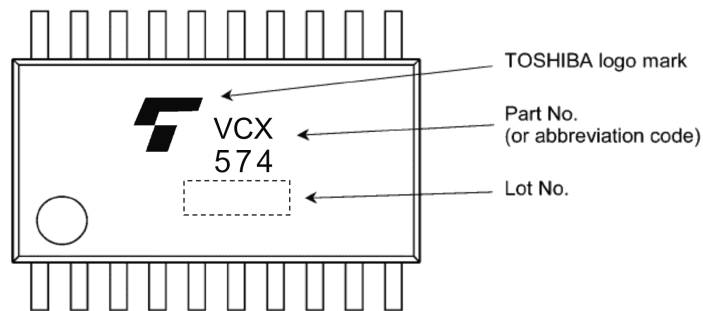
Start of commercial production

2020-04

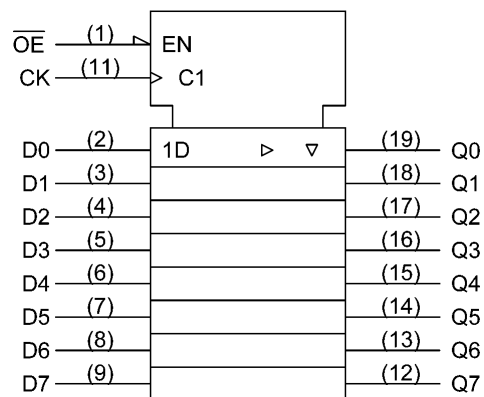
5. Pin Assignment






6. Marking



7. IEC Logic Symbol

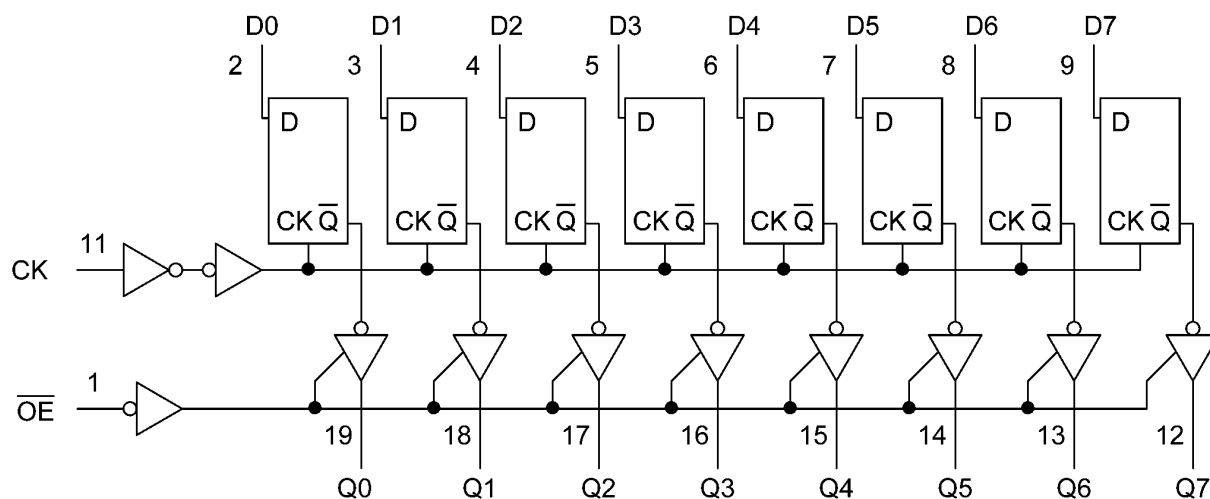


8. Truth Table

Inputs			Outputs
\overline{OE}	CK	D	
H	X	X	Z
L		X	Q _n
L		L	L
L		H	H

X: Don't care
 Z: High impedance
 Q_n: No change

9. System Diagram



10. Absolute Maximum Ratings (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		-0.5 to 4.6	V
Input voltage	V_{IN}		-0.5 to 4.6	V
Output voltage	V_{OUT}	(Note 1)	-0.5 to 4.6	V
		(Note 2)	-0.5 to $V_{CC} + 0.5$	
Input diode current	I_{IK}		-50	mA
Output diode current	I_{OK}	(Note 3)	± 50	mA
Output current	I_{OUT}		± 50	mA
Power dissipation	P_D	(Note 4)	180	mW
V_{CC} /ground current	I_{CC}/I_{GND}		± 100	mA
Storage temperature	T_{stg}		-65 to 150	$^{\circ}C$

Note: Exceeding any of the absolute maximum ratings, even briefly, lead to deterioration in IC performance or even destruction.

Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.

Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook ("Handling Precautions"/"Derating Concept and Methods") and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Note 1: Output in OFF state.

Note 2: High (H) or Low (L) state. I_{OUT} absolute maximum rating must be observed.

Note 3: $V_{OUT} < GND$, $V_{OUT} > V_{CC}$

Note 4: 180 mW in the range of $T_a = -40$ to $85^{\circ}C$. From $T_a = 85$ to $125^{\circ}C$ a derating factor of -3.25 mW/ $^{\circ}C$ shall be applied until 50 mW.

11. Operating Ranges (Note)

Characteristics	Symbol	Note	Rating	Unit
Supply voltage	V_{CC}		1.2 to 3.6	V
Input voltage	V_{IN}		-0.3 to 3.6	V
Output voltage	V_{OUT}	(Note 1)	0 to 3.6	V
		(Note 2)	0 to V_{CC}	
Output current	I_{OH}, I_{OL}	(Note 3)	± 24	mA
		(Note 4)	± 18	
		(Note 5)	± 6	
		(Note 6)	± 2	
Operating temperature	T_{opr}	(Note 7)	-40 to 125	$^{\circ}C$
Input rise and fall times	dt/dv	(Note 8)	0 to 10	ns/V

Note: The operating ranges must be maintained to ensure the normal operation of the device.

Unused inputs must be tied to either V_{CC} or GND.

Note 1: Output in OFF state.

Note 2: High (H) or Low (L) state.

Note 3: $V_{CC} = 3.0$ to 3.6 V

Note 4: $V_{CC} = 2.3$ to 2.7 V

Note 5: $V_{CC} = 1.65$ to 1.95 V

Note 6: $V_{CC} = 1.4$ to 1.6 V

Note 7: Operating Range spec of $T_{opr} = -40^{\circ}C$ to $125^{\circ}C$ is applicable only for the products which manufactured after April 2020.

Note 8: $V_{IN} = 0.8$ to 2.0 V, $V_{CC} = 3.0$ V

12. Electrical Characteristics

12.1. DC Characteristics (Unless otherwise specified, $T_a = -40$ to 85 °C)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Max	Unit	
High-level input voltage	V_{IH}	—	1.2 to 1.4	$V_{CC} \times 0.8$	—	V	
			1.4 to 1.65	$V_{CC} \times 0.65$	—		
			1.65 to 2.3	$V_{CC} \times 0.65$	—		
			2.3 to 2.7	1.6	—		
			2.7 to 3.6	2.0	—		
Low-level input voltage	V_{IL}	—	1.2 to 1.4	—	$V_{CC} \times 0.05$	V	
			1.4 to 1.65	—	$V_{CC} \times 0.05$		
			1.65 to 2.3	—	$V_{CC} \times 0.2$		
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
High-level output voltage	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.65	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2$ mA	1.4	1.05	—	
				$I_{OH} = -6$ mA	1.65	1.25	
			$I_{OH} = -12$ mA		2.3	2.0	
				$I_{OH} = -12$ mA	2.3	1.8	
			$I_{OH} = -18$ mA		2.7	2.2	
				$I_{OH} = -18$ mA	2.3	1.7	
			$I_{OH} = -18$ mA		3.0	2.4	
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}		$I_{OL} = 100 \mu A$	1.2	—	0.05
			1.4 to 1.65		—	0.05	
			1.65 to 3.6		—	0.2	
			$I_{OL} = 2$ mA	1.4	—	0.35	
				$I_{OL} = 6$ mA	1.65	—	0.3
			$I_{OL} = 12$ mA		2.3	—	0.4
				$I_{OL} = 12$ mA	2.7	—	0.4
			$I_{OL} = 18$ mA		2.3	—	0.6
				$I_{OL} = 18$ mA	3.0	—	0.4
			$I_{OL} = 24$ mA		3.0	—	0.55
Input leakage current	I_{IN}	$V_{IN} = 0$ to 3.6 V		1.2 to 3.6	—	± 5.0	μA
3-state output OFF-state leakage current	I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0$ to 3.6 V	1.2 to 3.6	—	± 10.0	μA	
Power-OFF leakage current	I_{OFF}	$V_{IN}/V_{OUT} = 0$ to 3.6 V	0	—	10.0	μA	
Quiescent supply current	I_{CC}	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	20.0	μA	
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V	1.2 to 3.6	—	± 20.0		
	ΔI_{CC}	$V_{IH} = V_{CC} - 0.6$ V (per input)	2.7 to 3.6	—	750	μA	

12.2. DC Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to 125 °C)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Min	Max	Unit	
High-level input voltage	V_{IH}	—	1.2 to 1.4	$V_{CC} \times 0.8$	—	V	
			1.4 to 1.65	$V_{CC} \times 0.65$	—		
			1.65 to 2.3	$V_{CC} \times 0.65$	—		
			2.3 to 2.7	1.6	—		
			2.7 to 3.6	2.0	—		
Low-level input voltage	V_{IL}	—	1.2 to 1.4	—	$V_{CC} \times 0.05$	V	
			1.4 to 1.65	—	$V_{CC} \times 0.05$		
			1.65 to 2.3	—	$V_{CC} \times 0.2$		
			2.3 to 2.7	—	0.7		
			2.7 to 3.6	—	0.8		
High-level output voltage	V_{OH}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OH} = -100 \mu A$	1.2	$V_{CC} - 0.1$	—	V
				1.4 to 1.65	$V_{CC} - 0.2$	—	
				1.65 to 3.6	$V_{CC} - 0.2$	—	
			$I_{OH} = -2$ mA	1.4	1.05	—	
				1.65	1.25	—	
			$I_{OH} = -6$ mA	2.3	2.0	—	
				2.3	1.8	—	
			$I_{OH} = -12$ mA	2.7	2.2	—	
				2.3	1.6	—	
			$I_{OH} = -18$ mA	3.0	2.4	—	
3.0	2.2	—					
Low-level output voltage	V_{OL}	$V_{IN} = V_{IH}$ or V_{IL}	$I_{OL} = 100 \mu A$	1.2	—	0.05	V
				1.4 to 1.65	—	0.05	
				1.65 to 3.6	—	0.2	
			$I_{OL} = 2$ mA	11.4	—	0.35	
			$I_{OL} = 6$ mA	1.65	—	0.3	
			$I_{OL} = 12$ mA	2.3	—	0.4	
				2.7	—	0.4	
			$I_{OL} = 18$ mA	2.3	—	0.8	
				3.0	—	0.4	
			$I_{OL} = 24$ mA	3.0	—	0.55	
Input leakage current	I_{IN}	$V_{IN} = 0$ to 3.6 V	1.2 to 3.6	—	± 20.0	μA	
3-state output OFF-state leakage current	I_{OZ}	$V_{IN} = V_{IH}$ or V_{IL} $V_{OUT} = 0$ to 3.6 V	1.2 to 3.6	—	± 40.0	μA	
Power-OFF leakage current	I_{OFF}	$V_{IN}/V_{OUT} = 0$ to 3.6 V	0	—	40.0	μA	
Quiescent supply current	I_{CC}	$V_{IN} = V_{CC}$ or GND	1.2 to 3.6	—	80.0	μA	
		$V_{CC} \leq (V_{IN}/V_{OUT}) \leq 3.6$ V	1.2 to 3.6	—	± 80.0		
	ΔI_{CC}	$V_{IH} = V_{CC} - 0.6$ V (per input)	2.7 to 3.6	—	1.5	mA	

Note: Operating Range spec of $T_{opr} = -40$ °C to 125 °C is applicable only for the products which manufactured after April 2020.

12.3. AC Characteristics (Unless otherwise specified, $T_a = -40$ to 85 °C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{MAX}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	40	—	MHz
				1.5 ± 0.1	80	—	
				1.8 ± 0.15	100	—	
				2.5 ± 0.2	200	—	
				3.3 ± 0.3	250	—	
Propagation delay time (CK-Q)	t_{PLH}, t_{PHL}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	1.5	48.0	ns
				1.5 ± 0.1	1.0	19.2	
				1.8 ± 0.15	1.5	9.6	
				2.5 ± 0.2	0.8	4.8	
				3.3 ± 0.3	0.6	4.2	
3-state output enable time	t_{PZL}, t_{PZH}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1	1.2	1.5	49.0	ns
				1.5 ± 0.1	1.0	19.6	
				1.8 ± 0.15	1.5	9.8	
				2.5 ± 0.2	0.8	5.5	
				3.3 ± 0.3	0.6	4.5	
3-state output disable time	t_{PLZ}, t_{PHZ}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1	1.2	1.5	32.5	ns
				1.5 ± 0.1	1.0	13.0	
				1.8 ± 0.15	1.5	6.5	
				2.5 ± 0.2	0.8	3.6	
				3.3 ± 0.3	0.6	3.3	
Minimum pulse width (CK)	$t_{w(L)}, t_{w(H)}$		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	24.0	—	ns
				1.5 ± 0.1	8.0	—	
				1.8 ± 0.15	4.0	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum setup time	t_s		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	20.0	—	ns
				1.5 ± 0.1	7.5	—	
				1.8 ± 0.15	2.5	—	
				2.5 ± 0.2	1.5	—	
				3.3 ± 0.3	1.5	—	
Minimum hold time	t_h		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	8.0	—	ns
				1.5 ± 0.5	3.0	—	
				1.8 ± 0.15	1.0	—	
				2.5 ± 0.2	1.0	—	
				3.3 ± 0.3	1.0	—	
Output skew	t_{osLH}, t_{osHL}	(Note 1)	—	1.2	—	1.5	ns
				1.5 ± 0.1	—	1.5	
				1.8 ± 0.15	—	0.5	
				2.5 ± 0.2	—	0.5	
				3.3 ± 0.3	—	0.5	

Note 1: Parameter guaranteed by design. ($t_{osLH} = |t_{PLHM} - t_{PLHN}|$, $t_{osHL} = |t_{PHLM} - t_{PHLN}|$)

12.4. AC Characteristics (Note) (Unless otherwise specified, $T_a = -40$ to 125 °C)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Min	Max	Unit
Maximum clock frequency	f_{MAX}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	30	—	MHz
				1.5 ± 0.1	70	—	
				1.8 ± 0.15	80	—	
				2.5 ± 0.2	150	—	
				3.3 ± 0.3	200	—	
Propagation delay time (CK-Q)	t_{PLH}, t_{PHL}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	1.5	63.0	ns
				1.5 ± 0.1	1.0	24.4	
				1.8 ± 0.15	1.5	11.4	
				2.5 ± 0.2	0.8	5.7	
				3.3 ± 0.3	0.6	5.0	
3-state output enable time	t_{PZL}, t_{PZH}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1	1.2	1.5	60.0	ns
				1.5 ± 0.1	1.0	23.2	
				1.8 ± 0.15	1.5	11.6	
				2.5 ± 0.2	0.8	6.5	
				3.3 ± 0.3	0.6	5.4	
3-state output disable time	t_{PLZ}, t_{PHZ}		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.2, Table 12.8.1	1.2	1.5	41.5	ns
				1.5 ± 0.1	1.0	15.6	
				1.8 ± 0.15	1.5	7.8	
				2.5 ± 0.2	0.8	4.4	
				3.3 ± 0.3	0.6	4.0	
Minimum pulse width (CK)	$t_{w(L)}, t_{w(H)}$		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	26.0	—	ns
				1.5 ± 0.1	8.7	—	
				1.8 ± 0.15	4.4	—	
				2.5 ± 0.2	1.7	—	
				3.3 ± 0.3	1.7	—	
Minimum setup time	t_s		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	21.0	—	ns
				1.5 ± 0.1	7.9	—	
				1.8 ± 0.15	2.7	—	
				2.5 ± 0.2	1.6	—	
				3.3 ± 0.3	1.6	—	
Minimum hold time	t_h		See 12.7 AC Test Circuit, Table 12.7.1, Fig. 12.8.1, Table 12.8.1	1.2	8.4	—	ns
				1.5 ± 0.1	3.2	—	
				1.8 ± 0.15	1.1	—	
				2.5 ± 0.2	1.1	—	
				3.3 ± 0.3	1.1	—	
Output skew	t_{osLH}, t_{osHL}	(Note 1)	—	1.2	—	2.0	ns
				1.5 ± 0.1	—	2.0	
				1.8 ± 0.15	—	1.0	
				2.5 ± 0.2	—	1.0	
				3.3 ± 0.3	—	1.0	

Note: Operating Range spec of $T_{opr} = -40$ °C to 125 °C is applicable only for the products which manufactured after April 2020.

Note 1: Parameter guaranteed by design. ($t_{osLH} = |t_{PLHM} - t_{PLHN}|$, $t_{osHL} = |t_{PHLM} - t_{PHLN}|$)

12.5. Dynamic Switching Characteristics (Note)

(Unless otherwise specified, $T_a = 25^\circ\text{C}$, Input: $t_r = t_f = 2.0 \text{ ns}$, $C_L = 30 \text{ pF}$)

Characteristics	Symbol	Test Condition	V_{CC} (V)	Typ.	Unit
Quiet output maximum dynamic V_{OL}	V_{OLP}	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	0.25	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	0.6	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	0.8	
Quiet output minimum dynamic V_{OL}	V_{OLV}	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	-0.25	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	-0.6	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	-0.8	
Quiet output minimum dynamic V_{OH}	V_{OHV}	$V_{IH} = 1.8 \text{ V}, V_{IL} = 0 \text{ V}$	1.8	1.5	V
		$V_{IH} = 2.5 \text{ V}, V_{IL} = 0 \text{ V}$	2.5	1.9	
		$V_{IH} = 3.3 \text{ V}, V_{IL} = 0 \text{ V}$	3.3	2.2	

Note: Parameter guaranteed by design.

12.6. Capacitive Characteristics (Unless otherwise specified, $T_a = 25^\circ\text{C}$)

Characteristics	Symbol	Note	Test Condition	V_{CC} (V)	Typ.	Unit
Input capacitance	C_{IN}		—	1.8, 2.5, 3.3	6	pF
Output capacitance	C_{OUT}		—	1.8, 2.5, 3.3	7	pF
Power dissipation capacitance	C_{PD}	(Note 1)	$f_{IN} = 10 \text{ MHz}$	1.8, 2.5, 3.3	20	pF

Note 1: C_{PD} is defined as the value of the internal equivalent capacitance which is calculated from the operating current consumption without load. Average operating current can be obtained by the equation.

$$I_{CC(opr)} = C_{PD} \times V_{CC} \times f_{IN} + I_{CC}/8 \text{ (per 1 gate)}$$

12.7. AC Test Circuit

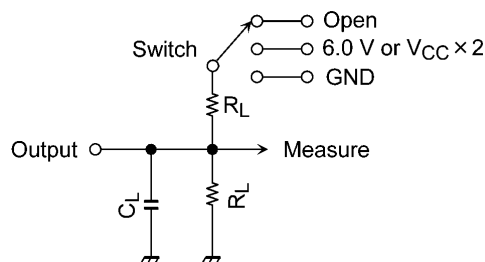


Table 12.7.1 Parameter for AC Test Circuit

Parameter	Switch	Test Condition
t_{PLH}, t_{PHL}	OPEN	—
t_{PLZ}, t_{PZL}	$V_{CC} \times 2$	$V_{CC} = 3.3 \pm 0.3 \text{ V}$
		$V_{CC} = 2.5 \pm 0.2 \text{ V}$
		$V_{CC} = 1.8 \pm 0.15 \text{ V}$
		$V_{CC} = 1.5 \pm 0.1 \text{ V}$
t_{PHZ}, t_{PZH}	GND	—

12.8. AC Waveform

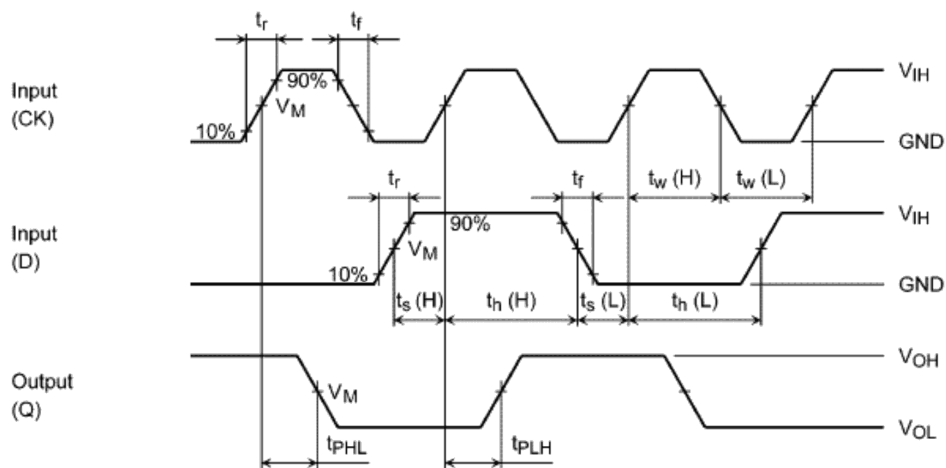


Fig. 12.8.1 t_{PLH} , t_{PHL} , t_w , t_s , t_h

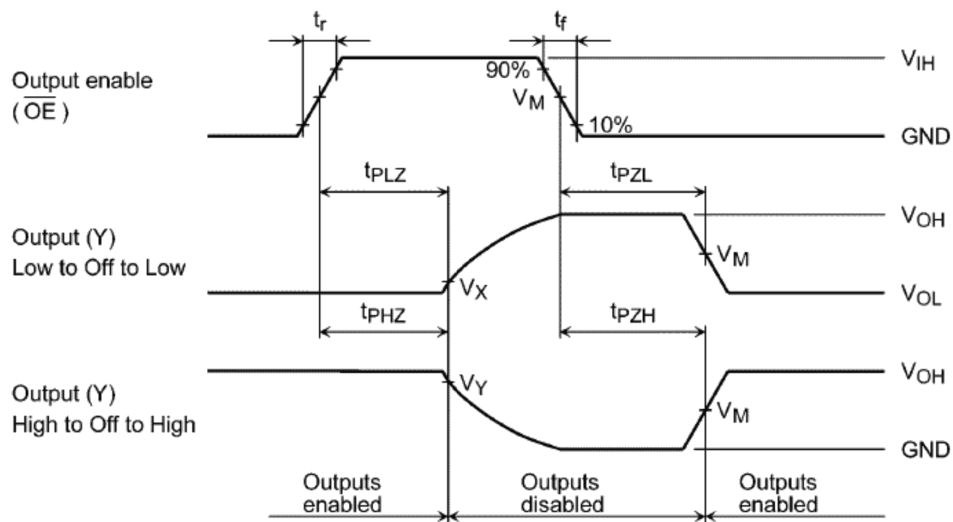


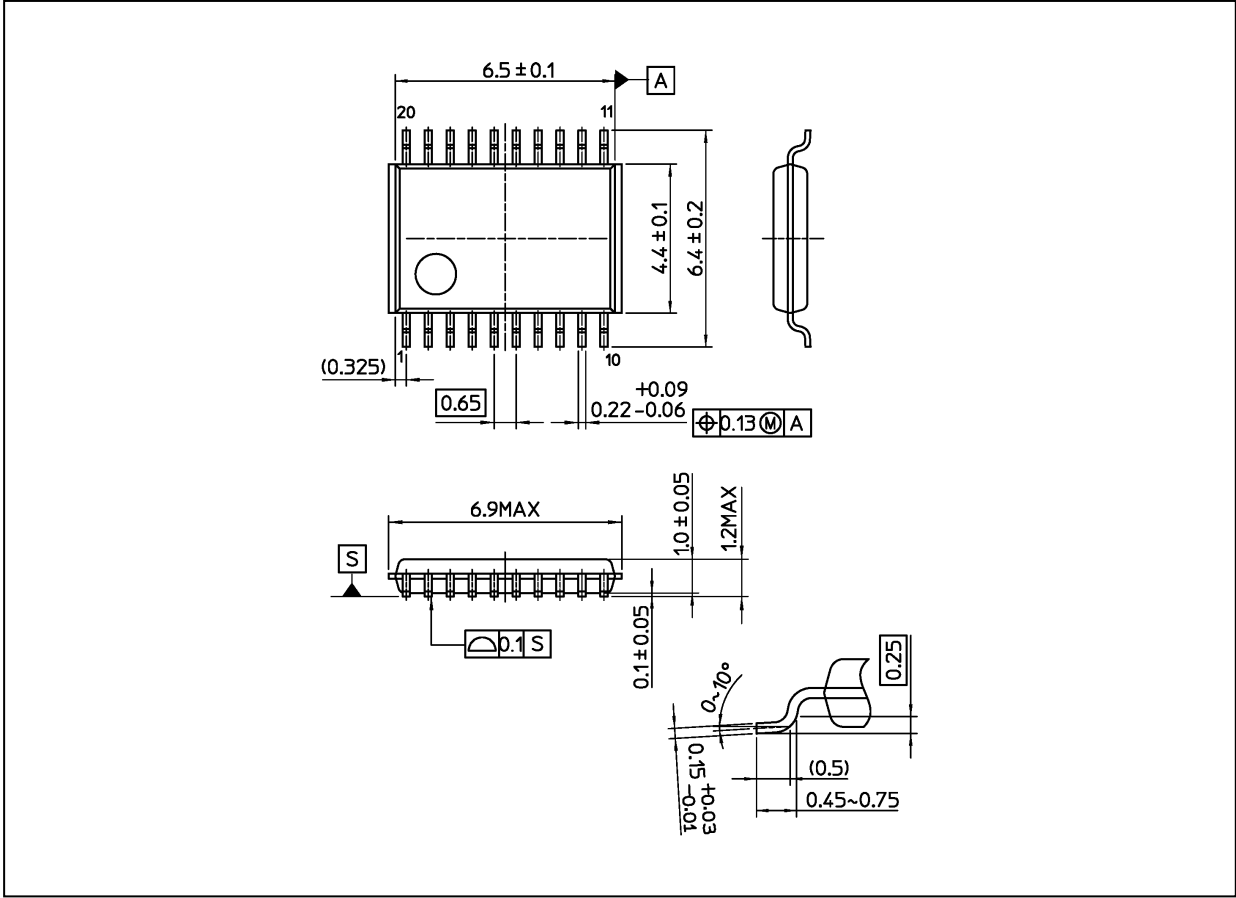
Fig. 12.8.2 t_{PLZ} , t_{PHZ} , t_{PZL} , t_{PZH}

Table 12.8.1 AC Waveform Symbols

	Symbol	$V_{CC} = 3.3 \pm 0.3 \text{ V}$	$V_{CC} = 2.5 \pm 0.2 \text{ V}$ $V_{CC} = 1.8 \pm 0.15 \text{ V}$	$V_{CC} = 1.5 \pm 0.1 \text{ V}$ $V_{CC} = 1.2 \text{ V}$
Input	V_{IH}	2.7 V	V_{CC}	V_{CC}
	V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	t_r, t_f	2.0 ns	2.0 ns	2.0 ns
Output	V_M	1.5 V	$V_{CC}/2$	$V_{CC}/2$
	V_X	$V_{OL} + 0.3 \text{ V}$	$V_{OL} + 0.15 \text{ V}$	$V_{OL} + 0.15 \text{ V}$
	V_Y	$V_{OH} - 0.3 \text{ V}$	$V_{OH} - 0.15 \text{ V}$	$V_{OH} - 0.15 \text{ V}$
Load	C_L	30 pF	30 pF	15 pF
	R_L	500 Ω	500 Ω	2 k Ω

Package Dimensions

Unit: mm



Weight: 0.08 g (typ.)

Package Name(s)
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